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2.0 SITE HISTORICAL OVERVIEW

2.1 SITE DESCRIPTION

This section provides an overview site description for the four facilities addressed in the DOE Ohio field Office Recycled Uranium Project report; the Fernald Environmental Management Project (FEMP), the RMI Environmental Services site (RMI), the West Valley Demonstration Project (WVDP), and the Weldon Spring Site Remedial Action Project (WSSRAP). Each of these sites were identified in the February 2000 Historical Generation and Flow of Recycled Uranium in the DOE Complex as either Tier 1 or Tier 2 sites. Since the recycle of irradiated uranium began in the 1950s, a significant portion of the desired data and records were generated 40+ years ago and in many cases have been archived, lost, or destroyed. In addition, much of the data and records generated during the sites' production years were closely controlled due to national security and classification requirements that were designed to reinforce a "need to know" environment. As such, recent searches of previously classified historical data have resulted in the identification of data gaps and/or less than complete records for the receipt and shipment of uranium materials within the complex. These gaps appear to have resulted from the destruction of classified information in lieu of declassifying the data. Furthermore, the "need to know" environment also is a probable contributor to difficulties encountered in attempting to reconstruct information based on the use of former site workers and process knowledge since these individuals, in most instances, only dealt with information and data for their work area or facility. The DOE Ohio Field Office team has conscientiously attempted to research and obtain historical information and data for use in the development of this report and believe the best available information concerning the four facilities has been utilized.

2.1.1 FEMP

Following the end of World War II, the Cold War emerged as a new era of international tensions that lasted for decades. Our nation established a policy of placing the destructive capability of nuclear weapons under civilian control by creating the Atomic Energy Commission (AEC) in 1946. The New York Operations Office of the AEC managed the Manhattan Project and determined there was an immediate need for a new production facility capable of processing uranium ores to a high-quality finished metal products. Construction of this new Feed Materials Production Center (FMPC), now known as the FEMP began in 1951 on a 1,050-acre site located on the boundary between Hamilton and Butler counties near the small rural community of Fernald, Ohio. The AEC awarded a prime contract to National Lead Company of Ohio (NLO) in 1951, for the management and operation of the FEMP.

NLO's contractual relationship lasted until January 1986, when Westinghouse Materials Company of Ohio (WMCO) began its contract with DOE to continue the management and operation of the site. With the end of the Cold War in 1989, the DOE mission transitioned from national defense programs to environmental restoration and the site was renamed Fernald Environmental Management Project (FEMP). In 1991, WMCO became the Westinghouse Environmental Management Company of Ohio (WEMCO) to correspond with the name change from FMPC to FEMP. Another contractor change occurred in December 1992, when DOE awarded its first-ever environmental restoration management contract to the Fernald Environmental Restoration Management Corporation (FERMCO), now called Fluor Fernald, Inc.

The FEMP workforce was a unique combination of highly skilled occupational personnel and professionals having expertise in chemical and metallurgical process technologies. Fernald clearly established a reputation that was well known throughout DOE for producing the highest quality uranium metal products. The workforce took pride in the quality of their products and in their timely delivery to customers. Employment peaked at 2,891 in 1956, and then slowly declined to reach an eventual low of 538 in 1979. During the late 1970s, this technical and manufacturing expertise provided key support to the emerging penetrator program by the Department of Defense (DOD). The site played a significant role in the development of manufacturing, methods, and testing that led to the selection and eventual production of uranium alloy used by the military.

Site Mission

Fernald's primary mission during nearly 40 years of operation was the manufacture of uranium metal products in a variety of configurations. Large-scale chemical treatment operations were integrated with metal production and fabrication processes to carry out the production mission. Uranium metal cores were used to make plutonium in nuclear reactors located at other DOE sites. Metal production for non-reactor uses became significant during the 1980s.

In July 1989, all production activity was suspended to focus attention on attaining full compliance with environmental regulations and safety standards. In October 1990, DOE began transitioning the uranium production mission of Defense Programs to the to the environmental restoration Office of Environmental Restoration and Waste Management. In February 1991, DOE announced its intention to formally end the production mission and submitted a closure plan to Congress, which became effective in June 1991.

The Remedial Investigation and Feasibility Studies for the site (five operable units) were completed in 1996 and the Records of Decision have been finalized and approved. Remedial Actions have been

initiated and over twenty facilities and structures have been decommissioned and dismantled. A significant portion of the remedial wastes are being placed in the On-Site Disposal Facility. All cleanup activities are scheduled to be completed by the end of FY-2008.

Production Operations

The FEMP consisted of ten production plants, each having a specific mission that supplied the succeeding plant with an intermediate product for further processing until the eventual uranium form was produced. A detailed description of the production processes performed by each plant is presented in Appendix D, Section 1. Operations began in October 1951, with the completion of the Pilot Plant as an operating prototype of the entire production process to develop performance data for designing large-scale equipment. At the same time, limited quantities of uranium metal were produced. The three metal production and fabrication plants became operational by 1953, and all five chemical plants one year later.

Table 2-1 is the summary of all receipts and shipments at the FEMP in metric tons of uranium. Shipments are higher than receipts due to limiting the envelope for data to after recycled uranium started, i.e., not including the years prior to 1962 at the FEMP. A further breakdown of material by sites is included in Section 3.1.1 and Appendix A, Section 1.

TABLE 2-1

FEMP SUMMARY OF RECEIPTS AND SHIPMENTS

	Recycled Uranium Receipts (1962-1999) (MTU)	Recycled Uranium Shipments (1962-1999) (MTU)	Total Receipts (1952-1999) (MTU)	Total Shipments (1952-1999) (MTU)
Enriched	60,180.7	60,305.6	64,939.4	64,144.1
Normal	89,649.2	94,852.8	193,156.5	193,047.8
Depleted	96,853.2	94,071.1	105,485.9	102,678.9
Total	246,683.1	249,229.5	363,581.8	359,870.8

Uranium Production

Fernald supplied a large variety of sizes, shapes and isotopic levels of uranium metal products for user sites during nearly 38 years of production operations. From 1951 to 1989, enriched, normal and depleted uranium cores and target fuel element cores totaling 181,000 MTU were shipped to the various reactor sites. The remaining 52,300 MTU was shipped to various other locations. During the same period, some 40,000 MTU of normal and enriched uranium contained in process residues were recovered in Plant 8. Uranium derby production peaked at 10,586 MTU in 1960, supporting deliveries of finished metal

products at the 8,000 MTU per year level through 1965. Annual declines followed which eventually reached a low of about 800 MTU in 1975.

2.1.2 RMI

Beginning in 1962 the primary function of RMI was to extrude depleted, normal, and slightly enriched uranium (up to 2.1percent U-235) metal for the DOE. The uranium was extruded into rods, tubes, or other shapes as an intermediate step in the production of nuclear fuel elements at other DOE sites. These fuel elements were for plutonium production reactors at the Hanford site in Washington and the Savannah River Site in South Carolina.

RMI also extruded depleted and natural uranium under Nuclear Regulatory Commission (NRC) license SMB-602. However, the majority of the material processed at the facility was for the DOE. Uranium extrusion work ceased in September 1988 and all extrusion operations at RMI ceased on October 31, 1990. All uranium extrusion work was performed under an exclusion section in the Atomic Energy Act and/or NRC license during the production life of the site. A further breakdown of material by program is included in Section 3.1.2 and Appendix A, Section 2. The following table summarizes the material balance for the RMI Facility:

TABLE 2-2

RMI SUMMARY OF RECEIPTS AND SHIPMENTS

	Recycled Uranium Receipts (1962-1999) (MTU)	Recycled Uranium Shipments (1962-1999) (MTU)	Total Receipts (1952-1999) (MTU)	Total Shipments (1952-1999) (MTU)
Enriched	25,327.4	25,269.8	25,327.4	25,269.8
Normal	5,236.0	5,181.8	5,236.0	5,181.8
Depleted	46,158.5	45,722.7	46,158.5	45,722.7
Total	76,721.9	76,174.3	76,721.9	76,174.3

The NRC approved the RMI Decommissioning Plan in September 1997. The current mission of the facility is to decommission the site for unrestricted use. During decommissioning, activities are being directed toward reducing residual radioactive contamination to a level that permits the site and adjacent areas to be released for unrestricted use. Decommissioning activities include decontamination of equipment, materials, facilities, and soils if practicable, to levels releasable for unrestricted use; and demolition and removal of items unable to be decontaminated. All wastes will be disposed of in accordance with approved procedures.

2.1.3 WVDP

The West Valley Facility was the first and only private plant in the U.S. to reprocess spent nuclear fuel. The facility was granted a license in 1965 to receive and store fuel for reprocessing. The reprocessing of plutonium spent nuclear fuel has identified the WVDP as a source facility for the purpose of this report and will not have any receipts of recycled uranium. The shipment of fuel assemblies to the facility continued through 1972. Fuel reprocessing was halted in 1972 to increase reprocessing capacity and upgrade the facility to meet new regulatory requirements. However, the facility ceased reprocessing operations in 1976. The West Valley Facility was a PUREX (Plutonium Uranium Extraction) process plant, with remote handling capabilities, with a design capacity of 300 tons of fuel per year. During the reprocessing of materials a total of 620 MTU was recovered and this material was shipped to the FEMP for additional processing. The WVDP also made shipments of approximately 1.2 MTU to the Oak Ridge Y-12 facility in the 1970-1971 timeframe. The following table summarizes the receipts and shipments made by WVDP and a breakdown of the amounts generated during the 27-campaign history is included in Section 3.1.3 and Appendix A, Section 3.

Table 2-3

WVDP SUMMARY OF RECEIPTS AND SHIPMENTS

	Recycled Uranium Receipts (1962-1999) (MTU)	Recycled Uranium Shipments (1962-1999) (MTU)	Total Receipts (1952-1999) (MTU)	Total Shipments (1952-1999) (MTU)
Enriched	0	464.4	0	464.4
Normal	0	12.9	0	12.9
Depleted	0	142.1	0	142.1
Total	0	619.4	0	619.4

The PUREX process included storing spent fuel assemblies; chopping the assembly rods; dissolving the uranium, plutonium, and radioactive products in acid; separating and storing the radioactive wastes, and separating uranium nitrate from plutonium nitrate. After 1976 the facility's mission turned to management and long-term storage of high-level radioactive liquids and sludge. In 1980, the West Valley Demonstration Project Act (WVDPA) was passed that directed the DOE to solidify the high-level

Radioactive waste into a borosilicate glass that was suitable for permanent storage in an approved federal repository. In addition, the WVDPA directed the DOE to decontaminate and decommission the tanks and facilities and dispose of the low level and transuranic wastes.

2.1.4 WSSRAP

The primary mission of Weldon Spring, during its ten years of operation, was the processing of uranium and thorium into metal and intermediate products. The site was acquired from the U.S. Army, which had produced ammonium nitrate explosives. The facility was designed and built specifically to process uranium ore concentrates (yellow cake) produced at mill sites in western United States and Canada. These materials were shipped to the Weldon Spring Site for assay sampling to determine payment. Portions of the total ore concentrates recovered were processed through chemical treatment operations. The majority of the material processed through this facility was natural U, however, it has been included with the normal U category.

The Weldon Spring Site processed materials mainly from 1957 through 1966. The employment at the site for the Uranium Division numbered around 600 employees. Included in that number were 80 technical employees assigned to various production, technical and managerial positions. The estimate of those personnel that would have handled the materials is estimated as around 300. The majority of the material processed was natural uranium, however, depleted and slightly enriched uranium and natural thorium were also processed. Table 2-4 presents a summary of site material receipts and a further breakdown of this information is in Section 3.1.4 and Appendix A, Section 4.

TABLE 2-4

WSSRAP SUMMARY OF RECEIPTS AND SHIPMENTS

	Recycled Uranium Receipts (1962-1999) (MTU)	Recycled Uranium Shipments (1962-1999) (MTU)	Total Receipts (1952-1999) (MTU)	Total Shipments (1952-1999) (MTU)
Enriched	842.6	833.9	842.6	833.9
Normal (Natural)	70,538.4	73,878.4	122,015.9	121,901.2
Depleted	32.0	92.3	167.8	167.8
Total	71,413.0	74,804.6	123,026.3	122,902.9

The site was re-acquired by the Army in 1967 and decontamination and dismantling operations were initiated in 1968 to prepare for conversion to a herbicide production facility. The facility was never converted to this production due to costs and efforts to meet existent radioactive contamination limits. In FY-1986 DOE assumed custody of the facility. The facility was placed on the National Priorities List in July 1987 (quarry) and February 1990 (chemical plant). The site has completed extensive remediation including the establishment of an onsite disposal facility.

2.2 KEY URANIUM PROCESSING FACILITIES

2.2.1 FEMP Facilities

Overall Production Process

The historical production processes at the FEMP consisted of ten production plants, each having a specific mission that supplied the succeeding plant with an intermediate product for further processing until the eventual uranium form was produced. A schematic diagram of the overall production process is shown in Figure D-1, and a detailed description of each plant process, production activity, and significant events is presented in Appendix D, Section 1.

Operations began in October 1951, with the completion of the Pilot Plant as an operating prototype of the entire production process to develop performance data for designing large-scale equipment. At the same time, limited quantities of uranium metal were produced. In December 1953, the Sampling Plant (1) became operational and eventually was designated the official AEC sampling station for determining uranium and isotopic assays of uranium ores and concentrates. The three metal production and fabrication plants (5, 6, and 9) became operational by 1953 and all five chemical plants (2, 3, 4, 7, and 8) one year later. Subsequent to start-up, Plants 2 and 3 were generally operated as a single plant because of the integral process operations.

Extensive technical support was provided to the plants as operations moved through initial start-up to full-scale operation of the primary process streams. The Analytical Department personnel developed numerous methods of quantitative analyses, involving new techniques and applications of equipment. Hundreds of analytical methods were established for supporting the primary processes, ongoing technical development work and attendant changes. Numerous spot tests were devised for chemical operators to perform process quality control checks for ensuring conformance with manufacturing standards. A high performance standard was maintained in all operations through continual improvements of manufacturing methods, technology innovations, emphasis on safety and good housekeeping practices, and upgrades to work facilities.

Chemical Process Operations

The FEMP production process began with the conversion of impure uranium feed materials and recycled residues to produce pure uranium trioxide (UO_3) in the Ore Refinery Plant (2/3), beginning in December 1953. This was accomplished in a three-step operation that began with acid-leaching uranium from dry solid feed materials followed by solvent extraction processing to produce a highly pure solution

of uranyl nitrate (UNH). The final step was the conversion of pure UNH solution to UO_3 by thermal decomposition. Plant 2/3 was shut down in 1962, but limited operations were resumed within one year and continued intermittently until 1972, when the concentrate conversion campaign was started. During this five-year campaign, UO_3 product was shipped to the Paducah Gaseous Diffusion Plant instead of advancing to the Green Salt Plant (4) to support uranium metal production.

Plant 4 began operating in October 1953 for converting UO_3 that was either produced in Plant 2/3 or received from offsite to uranium tetrafluoride (UF_4), commonly called Green Salt, by a two-step operation. In the first step, UO_3 was reduced by hydrogen to form uranium dioxide (UO_2), which was then converted to green salt using anhydrous hydrofluoric acid in the second step. Green Salt was also produced in the Hexafluoride Reduction Plant (7) by a direct process that reduced uranium hexafluoride (UF_6) by hydrogen to form UF_4. Plant 7 operated for only three years, beginning in June 1954, to supplement the supply of green salt produced by Plant 4 in order to meet the peak metal demands of the mid-1950s. Green Salt product was the source material for making uranium metal derbies in the Metals Production Plant (5) beginning in May 1953.

The Scrap Recovery Plant (8) began operations in November 1953 for upgrading process residues to a form suitable for uranium recovery in Plant 2/3. Process residues were numerous forms of low-assay uranium materials that were generated by all production operations. Examples include magnesium fluoride (MgF_2) slag, sump filter cakes, dust collector materials, incinerator ash, and off-specification UO_3 and UF_4. Low-grade metal scrap that was unacceptable for recycling via remelting was furnaced to black oxide (U_3O_8). After screening, the fine material fraction became acceptable feed for Plant 2/3 operations and the coarse material fraction was further oxidized in a furnace.

Metal Production and Fabrication Operations

Plant 5 converted UF_4 into uranium derby metal by a thermite reduction process using magnesium metal granules. Derbies, so named because they were in the shape of a man's hat, weighed as much as 370 pounds. By-product MgF_2 slag was generated in substantial quantities by the reduction process. About half of the slag generated was milled for reuse as refractory liner in metal reduction pots. Surplus slag either underwent chemical treatment for uranium recovery or was discarded to the waste pits, depending upon the isotopic enrichment.

Derbies were cast into ingots along with high purity recycle metal scraps, either in Plant 5 or in Plant 9, depending upon the isotopic enrichment. Derbies were also shipped to other DOE sites. Dimensions of

cylindrical ingots were sized to the specific end-use configurations required by the reactor sites. As-cast ingots were cropped by sawing approximately 2 inches from the top section to remove shrinkage cavities and impurities that rose to the top of the melt during solidification. Cropped ingots were sent to the Special Products Plant (9) for center-drilling and surface machining or to the Rolling Mill in Plant 6. Uranium alloy produced for DOD applications were in a slab casting configuration. High-purity derbies were also shipped to other DOE sites after surface cleaning was performed.

In Mid-1952, the Rolling Mill and Machining Areas of the Metals Fabrication Plant (6) became operational for fabricating cropped ingots into finished uranium cores. Cylindrical cropped ingots having a diameter of 6-8 inches were heat treated prior to the rolling mill operation. Equipment in this operation consisted of an ingot furnace, blooming mill with reversing rolls, shearing devices, molten salt heat treating furnace, and conveyors. The blooming mill operation produced an oval billet having nominal diameter dimensions of 1¾ " x 2 ¼" elliptical diameters. After shearing and heat treating, the oval billets advanced to a six-stand finishing mill for machining into rod stock having standard diameters in the range of 1-2". In 1971, the rolling mill operation was shut down and all machined ingots were heat treated in Plant 6 before they were shipped to RMI Company for extrusion into tubes.

After straightening, the rod stock was transferred to the Machining Area for cutting into sections, center drilling, and surface machining to close tolerances specified for the final cores. The Machining Area had six automatic bar machines, four turret lathes, a degreasing and pickling facility, and press for compacting machining chips and turnings into briquettes. After final inspection, these final products were shipped to the user sites. Cores that failed to meet the rigorous quality standards were recycled through remelt operations in Plant 5. In 1962, the multi-station Cross Transfermatic Machine was installed and significantly increased the productivity of core machining operations.

Process and Operational Changes

One of the earliest productivity improvements resulted from the application of fluidization process technology in the Green Salt Plant (4) during the late 1950s. This innovative technology greatly increased the heat transfer rate and contact between gases and solids in the reduction of uranium trioxide to the dioxide using hydrogen. Another improvement was the use of costly exotic metals in the construction of ribbon-screw conveyors in the hydrofluorination process that converted uranium dioxide to green salt. This greatly reduced the corrosive effects that previously occurred with other metals, and resulted in higher on-line performance and product consistently meeting acceptance standards.

A significant process modification was made to the Plant 4 Hydrofluorination Banks to allow processing of Hanford UO_3. Once recycle of the uranium from Hanford began, it was determined that the Hanford UO_3 would not react as completely as the FEMP UO_3 and subsequent metal yield was adversely affected. To address this, one Plant 4 Hydrofluorination Bank was converted to chemically reduce the Hanford UO_3 to UO_2, UO_2 to U_3O_8, and U_3O_8 to UO_2 (reduction-oxidation-reduction or ROR), which could then be converted more completely to UF_4 in a Hydrofluorination Bank.

Significant operational changes were made in the early 1960's in Plant 2/3 as a result of process technology improvements. The Low-Acid Flowsheet eliminated the need for complex and elaborate equipment previously required for recovering nitrate values contained in wastewater. The Slag Leach recovery operation was implemented to recover uranium contained in surplus magnesium fluoride slag generated in the derby production process. The development of procedures and specialized equipment necessary to process this difficult material was a major contribution to the overall efficiency of plant operations.

With the cessation of operations in Plant 2/3 in 1962, limited activities were initiated to use part of the plant's facilities for recovering normal uranium process residues that had accumulated in the inventory. This operation became known as the Supplemental Recovery Facility (SRF), whose product was a solution of uranyl nitrate that was shipped to the Weldon Spring Refinery located in Missouri. When that site was closed in 1966, full operations were slowly implemented in Plant 2/3 to further reduce the sizable inventory of uranium residues and returning the uranium content to the production stream. By 1968, the conversion of the residue inventory to Refinery feeds was accomplished on a scale that surpassed all previous year totals. Residues that had previously required two runs for recovery could be recovered in one run and those requiring three runs were accomplished in two runs. During the 1970s, Fernald processed 77.3 million pounds of uranium contained in the DOE stockpile of ore concentrates to uranium trioxide in Plant 2/3 for use by the Paducah Gaseous Diffusion Plant.

In the Metal Production and Fabrication Plants (5, 6 and 9), the focal point for productivity improvement was improving production yields in the manufacture of derbies, ingots, and machined cores. This objective was accomplished not only by achieving high on-line performances, but also through consistently meeting high purity standards for these products. Uranium fabrication scraps of high purity were remelted into new ingots. The ZIRNLO process was developed and implemented in Plant 9 in 1963 for removing zirconium and copper metal claddings from reject fuel elements for recovery of uranium. About the same time, the highly automated Cross-Transfermatic Machine was installed in Plant 6 to serve

the multifunctional core machining operations. This machine was capable of performing the functions of exterior surface machining, interior surface reaming or grinding, and end facing of up to eight cores at the same time. Previously, each of these functions was performed one at a time for each core in a manpower intensive effort, requiring a large number of machining lathes. Requirements for both equipment and manpower were greatly reduced, while production throughputs and performance yields sharply increased.

Late in 1964, the first production of 1.95 percent of U-235 billets for Hanford was performed under closely controlled conditions to ensure nuclear criticality safety. Three different billet sizes were produced containing two different alloy compositions. Again, the unique blend of Fernald's technical expertise with skilled production workers adapted to the ever-changing demand by the user sites for different product metal configurations, dimensions, and isotopic assays. Fernald also played a major role in the development of the titanium-uranium alloy and manufacture of demonstration quantities of depleted uranium penetrators for the military.

A graphic that illustrates the time/quantity flow of enriched, normal, and depleted uranium by each FEMP production plant from FY-1960 through FY-1988 is included at the end of this Section, Figure 2-1, is discussed as follows. The annual metric tonnage of uranium (MTU) produced at the FEMP were, in some cases, the result of intermittent campaigns during the production year. In most cases, the graphic depiction of the production bar does not reflect these operational interruptions, as they are considered non-essential to a study of potential exposures versus production tonnage of recycled uranium (RU) material containing trace values of transuranic elements and/or fission products produced.

In some cases, the start/stop dates of some specific processes were judged to be significant and have been delineated. One such case is the WINLO operation in Plant 8 between 1962 and 1964. When historical production records data allowed, the specific dates for the introduction of recycled uranium (RU) into the production streams are indicated.

Other operational events considered to be significant are identified and detailed on the chart (Figure 2-1), plant by plant, are in the following table:

Table 2-5

FEMP RECYCLED URANIUM SIGNIFICANT OPERATIONAL EVENTS

Facility	Date	Discussion
Pilot Plant	February 13, 1961	Introduction of first RU, PO A-500, UF_6 to UF_4 process.
Plant 8	July 15, 1962	Introduction of first recycled U with start-up of WINLO process. The operation was terminated in April 1964, after sufficient inventories had been accumulated.
Plant 2/3	1963	Start of SRF campaign in which low grade residues were recovered through dissolution. The UNH product was shipped to Weldon Spring for conversion to metal.
	1964	The campaign of normal dissolution was extended to enriched residues, the campaign being re-designated E-SRF.
	July 30, 1965	Start of SERF campaign, the first introduction of RU into the Refinery, (Plant 2/3).
	1972	The installation of the safe geometry evaporator/calciner was completed with production starting late in the year converting enriched UNH to cascade quality U_3O_8. (2.0 to 5.0 percent enrichment)
	August 16 to September 11, 1964	First Plutonium Out Of Specification (POOS) occurrence.
	March 1 to March 25, 1985	Second POOS occurrence.
Plant 4	April 10, 1962	Introduction of first RU in Plant 4, PO A-508, Hydrofluorination.
	October 30, 1964	Conversion of SRP UO3, PO A-526.
	April 8, 1968	Conversion of Hanford Tails, 0.98 percent U-235, PO A-999.
	August 8, 1968	PNUR SRP Recycle, PO H-044 and PO H-045.
Plant 5 - Reduction	June 1965	Introduction of first RU to reduction process, PO A-500 and PO A-508.
Plant 5 - Casting	March 13, 1961	First casting of RU, PO A-500.
Plant 6 – Rolling	March 1, 1961	First rolling of RU, PO A-500.
	1978	Department of Defense (DoD) Special Rolling Operation.
Plant 9 – Reduction	February 17, 1961	First reduction of RU, PO A-500.
	October 1962	First reduction of RU, PO A-508.
Plant 9 – Casting	February 20, 1961	First casting of RU, PO A-500.
Plant 9 - Machining	March 2, 1961	First machining of RU, PO A-500.

2.2.2 RMI Facilities

The RMI Facility is located near Ashtabula, Ohio and consists of 23 buildings and approximately 32 acres. The primary processing activities took place in RF-6 Building. The extrusion process is discussed in Sections 2.1.2 and Appendix D, Section 2.

Figure 5-1 in Appendix D, Section 2 provides a general diagram of the process flow. The extrusion process involved the reshaping of metallic cylindrical ingots or billets into tubes, rods, or shaped forms by heating and forcing the material through a die utilizing a 3,850-ton Loewy horizontal extrusion press. This equipment was also used to form uranium metal in a closed die forging process.

The production process can be divided into three basic process streams: N-reactor production (Hanford), K and L Reactors production (Savannah River), and Department of Defense (DoD) penetrator production. Specifics for these process streams are included in Appendix D, Section 2.

The basics of the process for N-Reactor production are that the ingots were received from the FEMP (including inspection) and placed into storage. The ingots were heated to over 1,100°F in salt baths for a specified period of time. The ingots were extruded through the extrusion press into heavy walled tubes, cooled (water quench tank), cleaned, and inspected. Until the late 1960's the material was shipped back to the FEMP. After that time additional processing was performed. The additional processing included cutting into sections (billets), cleaning, inspection and heating prior to forging in the closed die press. The billets were cooled, cleaned, inspected, re-machined if required, and shipped.

For Savannah River product, the extrusion press formed tubing and after cooling, the tubing was cut into sections. The sections were heated (later not required) and run through a roll straightener. After straightening the sections were cleaned, inspected and shipped to the FEMP.

The DoD penetrator production was performed under RMI's NRC license between 1974 and 1985 to produce armor-piercing material. The process was the same used to produce Savannah River products except this material was air cooled prior to quenching and not run through the roll straightener.

2.2.3 WVDP Facilities

The only processing activity at the NFS facility in West Valley occurred in the Main Processing Plant. The plant was designed to facilitate the remote handling of spent reactor fuel and to separate and recover the uranium and plutonium. Fission products were separated from the product material and processed as liquid waste materials. The PUREX process was utilized for the recovery of uranium and plutonium.

The PUREX process utilized pulsed solvent extraction columns with a counter current flow of tributyl phosphate and kerosene. This organic solvent picks up the plutonium and uranium nitrates and the fission products remain and are removed in the aqueous phase. The recovered materials are extracted and concentrated together in the organic solvent and then purified by chemical scrubbing with dilute nitric acid. Two further cycles of solvent extraction and scrubbing each result in separate, concentrated, and purified aqueous solutions of plutonium nitrate and uranium nitrate.

2.2.4 WSSRAP Facilities

The key uranium processing facilities are described below. There are several key differences between the processing of uranium at the Weldon Spring Site and the FEMP. The ability for the FEMP to modify its process to meet ever-changing demands resulted in the Weldon Spring Site being shut down. An overview of the Weldon Spring processing facilities, capacities, and feedstocks is presented below. All of these facilities have been demolished. The majority of material processed at the WSSRAP was natural uranium.

Building 101 Sampling Plant: Designed to process approximately 75 tons of low-assay uranium ore concentrates per day. Housed equipment and facilities for drying, grinding, screening, blending, and sampling ore concentrates and process residues. Incoming ore concentrates and residues were stored in drums on the concrete pad.

Building 103 Digestion and Denitration: The northern digestion section received uranium ore concentrates which, after digestion were transferred as a slurry to Building 105 where the solution was purified by solvent extraction. The middle denitration section received the purified uranium nitrate solution, which was denitrated to yield UO_3. During later years, thorium products were also processed in this building.

Building 105 Extraction: Used for producing a highly purified UNH solution by means of extraction columns, process vessels, evaporators, and tributyl phosphate reaction tanks.

Building 201 Green Salt Building: Used for converting UO_3 to UO_2 and UF_4.

Building 301 Metals Building: Used for converting UF_4 to uranium metal.

Building 403 Chemical Pilot Plant: Designed to house pilot-plant equipment for testing modifications to processing carried out in the digestion, extraction, and denitration areas. Later uses also included processing of scrap metals and production of thorium.

Building 404 Metal Pilot Plant: Provided facilities for metal processing studies, ceramic work, and metal testing; also housed the metallurgical pilot plant.

2.3 SPECIAL OPERATIONS SUMMARIES

2.3.1 FEMP

Over a period of several years, a large inventory of uranium-bearing residues was accumulated at the Paducah Gaseous Diffusion Plant (GDP). Most of the residues were near normal in isotopic assay and were highly diverse in physical and chemical characteristics. Although much of the residue inventory was generated by Paducah site operations, a significant quantity of the scrap UF_4 was generated at the FEMP and shipped to Paducah for possible use as feed material in their operations. Very little of the UF_4 shipped from the FEMP was used at Paducah because their operation was suspended shortly after the transfer was completed.

By early 1975, the Paducah residue inventory contained approximately 400 MTU. After assessing the operational and environmental impacts of processing this inventory at Fernald, DOE Oak Ridge Operations Office (ORO) directed that the inventory be shipped to the FEMP for recovering the uranium in conjunction with the ore concentrate campaign that was in progress in Plant 2/3. The introduction of this inventory as a blend with ore concentrates began in 1976. Paducah continued shipping various types of residues after 1976. These materials were placed into FEMP's inventory of recoverable residues for eventual enriched uranium process campaigns in Plant 2/3. There were campaigns for enriched materials, high fluoride and low fluoride. The campaigns for depleted materials included high fluoride, low fluoride, and low-grade feeds.

Normal and enriched uranium scrap residues were received from the Oak Ridge (K-25) and Portsmouth Gaseous Diffusion Plants from 1966 through 1985. The characteristics of scraps received from these two sites were much different than those shipped by Paducah to the FEMP between 1976 and 1986. None of these materials were blended into the ore concentrate campaign conducted in Plant 2/3 from 1972 to 1977. A total of 597 MTU assaying in the range of 0.71percent to 5.0 percent U-235 was received at the FEMP from the Oak Ridge GDP. The Portsmouth GDP shipped approximately 32 MTU of 0.83 percent to 11.0 percent U-235 to the FEMP.

2.3.2 RMI

There were no identified special operations for RMI.

2.3.3 WVDP

There were no identified special operations for WVDP.

2.3.4 WSSRAP

There were no identified special operations for WSSRAP.

2.4 PROCESSES THAT POTENTIALLY CONCENTRATED RECYCLED URANIUM CONSTITUENTS

2.4.1 FEMP

Starting in 1961 the FEMP routinely received recycled uranium metal and compounds with trace quantities of transuranic constituent content for reuse in support of DOE Defense Programs. Except for a limited number of specific material receipts, these uranium materials received at the FEMP contained transuranics and other recycle constituents at levels below a concern for significant radiation exposure impacts. Because these constituents could possibly be concentrated in FEMP chemical processes, a review of these processes was performed during the development of this report.

A review of FEMP processes was completed by process-knowledge experts possessing knowledge of the entire production history of the FEMP from the operations startup period through shutdown. The review utilized existing process flow charts and process history narratives to identify possible points of constituent concentration/separation. The review included consideration of other known concentration/separation results identified during the operating history of the FEMP. The following section identifies those processes/process steps that were identified as having a basic chemical potential for concentration/separation of constituents, while also providing a rationale for such consideration.

Extraction

The extraction purification process for the FEMP was based on liquid/liquid countercurrent flows. The process was similar to the PUREX process that extracted plutonium and uranium from spent nuclear fuel at the Hanford and Savannah River DOE sites. At the FEMP, the process was adapted to purify the uranium of many gross contaminants and was not optimized for Pu or Np separation from uranium.

Several of the historical technical documents examined for this project predicted that approximately 80 percent of the Np and Pu would report to the aqueous raffinate from the extraction process. However, Plant Test (PTA) number 302 authorized and conducted in 1977 determined that 87.2 percent of the initial Pu and 41.6 percent of the initial Np remained in the product UO_3 stream of the process. These results were based on an overall material balance performed during and by PTA-302. The lesser decontamination provided by the process nonetheless results in Pu and Np reporting to both product and by-product stream (raffinate). The raffinate, which is low in uranium content by design, would be expected to present higher Pu and Np values than original feed materials to the process, when reported on a uranium assay basis (Pu/Np relative to U content). Extraction raffinate was neutralized and subsequently pumped to FEMP waste pits as a slurry.

UF_6 to UF_4 Process

This process was performed at Plant 7 and the Pilot Plant at the FEMP at different times in the operating history of the site. Although not designed to remove Pu or other constituents from the uranium stream, the UF_6 feed process allows the more volatile fractions of the UF_6 stream to preferentially exit the feed cylinder (much like a single stage separations process), while less volatile fractions would be less likely to leave the cylinder. Since Pu fluorides are known to have an affinity for zero valence metal elements and to produce less stable fluoride gasses, the potential for Pu to become relatively concentrated in the heel of the cylinder exists. Heels in cylinders were not further processed at the FEMP, but returned to the respective GDP for further use there.

Hydrofluorination

This process involved with the hydrofluorination of oxide powders is not believed to have permitted concentration of constituents because regardless of chemical reaction, the powders were mechanically or pneumatically moved through the solid-gas reaction processes from start to finish. However, the increased volatility of the Tc-99 in this high temperature process has been postulated to result in Tc-99 decontamination of the product stream at this process. By-product streams from this process were gases (N_2 and H_2 and anhydrous hydrogen fluoride from the respective steps of the operation). Equipment used to further filter, condense of scrub these gases may have exhibited Tc contamination.

Metal Reduction

The metal reduction process heated UF_4 powder mixed with magnesium metal granules in a lined and sealed vessel to initiate a reaction to form uranium metal. The uranium metal initially formed in a molten phase and quickly solidified in the base of the vessel. The effects of solubility of Pu and Np, and various

uranium decay daughter products in the molten uranium would determine the potential for separation of these constituents from the uranium. A study published in 1975 (NLCO-1130) reported that 46 percent of the initial Pu and 63 percent of the initial Np reported to the by-product MgF_2 slag in this process (decontaminating the product materials to 54 percent of the initial Pu and 37 percent of the initial Np).

This result is consistent with evidence from the casting operation that a significant portion of the higher radioactivity uranium daughter products (Thorium and Protactinium) tended to become excluded from the uranium matrix as the molten uranium solidified. The potential for a similar mechanism separating the transuranics at the reduction operation exists. Based on these results, the MgF_2 produced would be expected to have relatively higher levels of Pu and Np than the materials fed to the process. The majority of the MgF_2 was reutilized in subsequent processes, including milling of the material, followed by either reuse as new reduction pot liner material or processing in acid leaching operations to recover uranium content (for uranium above economic discard limits). Excess depleted MgF_2 was discarded directly to the FEMP waste pits or later shipped for off-site burial. Tailings from processing excess enriched and normal MgF_2 for uranium recovery were disposed to Waste Pits 3 and 5.

Vacuum Casting

The uranium casting operations utilized several different physical forms of uranium metal as feed. The ingots and billets produced in the casting operations often would exhibit higher surface radioactivity than materials fed to the process, indicating either a propensity for certain radioactive elements to be insoluble in molten uranium or potentially indicating an affinity between mold coating materials and certain radioactive species. This evidence provides a basis for postulating a Pu and Np separation from uranium at this process step. A study published in 1975 (NLCO-1130) reported that 5 percent of the initially fed Pu and 64 percent of the initially fed Np reported to the crucible residuals or graphite (or were otherwise not in the final metal product). Other results in the report claim a 40 percent share of Pu reporting to the crucible residuals. Processing of the ingot/billet following casting included mold separation (to remove the uranium from the graphite mold shape), cold saw cutting, and movement of the metal to acid pickling operation (see below). Similar materials remaining in the crucible were removed in a burnout operation that produced a crude U_3O_8 product for further processing at the FEMP.

Metal Pickling

Pickling the uranium metal products in nitric acid removed surface residues and oxides and generally reduced surface radioactivity dramatically. Because of the probable existence of relatively increased levels of constituents in surface residuals, spent pickling liquors may have contained relatively

concentrated (Pu/Np to U) fractions of constituents. These liquids would have been processed either in sump treatment operations to form sludges or sump cakes, or would have been returned to the Refinery as feed for recovery of uranium contents.

Machining Operations

A wide variety of machining operations were employed to shape uranium metal to product specifications. After most casting steps, the removal of a "top crop" was performed to separate porous and contaminated metal. It is likely that top crops contained greater quantities of recycled uranium constituents than the higher quality fraction of the metal product or the original casting feed materials. Top crops would either be refed to the casting operation or dissolved in acid (at a metal dissolver operation) for feed to the Refinery.

Scrap Recovery Operations

A number of operations utilized to recover scrap or residue uranium content were employed by the FEMP. A variety of milling capabilities supported oxidation/furnacing processes and a process for acid leaching of MgF_2. These and many other processes employed at the FEMP handled uranium in the form of a powder.

Qualitative Assessment of Airborne Conditions

The FEMP Site Report Team conducted a qualitative assessment of major site processes for airborne dust conditions arising from uranium processing operations at the FEMP. This assessment is based upon the experience and judgment of process knowledge experts who were employed at FEMP dating back to the start of operations in the 1950's. The range of expertise covers the full spectrum of uranium production operations and the types of materials that were handled and generated by each process. The plant-by-plant assessment only considered the potential for dust inhalation and not other forms of ingestion or human uptake.

Using the FEMP Lot Marking and Color Coding System described in Appendix C, the process knowledge team qualitatively assessed every source (SRC) operation that utilized and/or produced intermediate recycled uranium products/process residues from chemical processes or various forms of uranium metal/scraps from metal production and fabrication operations. The assessment assigned qualitative ratings of "low, medium, or high" to express the potential for dust exposure based upon the nature of the process, level of routine production activity, and operational frequency of the material handling process.

It should be recognized that FEMP production operations that involved handling dry uranium materials were typically equipped with engineered ventilation systems/equipment for controlling airborne dust. These systems/equipment included cyclone separators, bag house dust collectors, wet scrubbers, and portable vacuum systems that were specific to the operation. In addition, operational activities conducted in each plant were governed by a set of approved Manufacturing Standards comprised of Standard Operating Procedures (SOPs) and Manufacturing Specifications. The SOPs were a detailed set of operating instructions and safety requirements for conducting each step of the process. Safety requirements typically specified the use of respirators or dust masks for personnel protection when dusty conditions were expected to occur. An additional emphasis was placed upon maintaining good housekeeping practices and the immediate cleanup of spilled materials. The Manufacturing Specifications defined requirements for nuclear criticality safety, materials control and accountability, and performance specifications for raw materials, processes, and products.

The team rated processes for airborne dust potential as "high", "medium", or "low" based on the following criteria. Qualitative "high" potential ratings were assessed for high tonnage operations that were susceptible to occasional off-normal events. Examples of such events in the chemical plants were digestion area tank fuming and foam over and denitration pot eruptions in Plant 2/3; failure of the hydrofluorination banks in Plant 4; and temperature excursions in Plant 8 furnace operations. The major occurrences in the metals plants were blowout of metal reduction charges in Rockwell Furnaces and self-pour castings in Plant 5 and 9. In these off-normal situations, the installed ventilation systems were incapable of controlling dust emissions.

Another consideration for high potential exposure was the failure of the dust collector bags and blow ring devices or when workers were required to replace dust collector bags. In these instances, the process was typically shut down if an alternate online dust collector could not be provided. Operational practices included requirements for the production process operator to clean uranium materials from the dust collector unit and bags before releasing the equipment to Maintenance for bag replacement and return to service. This same practice of equipment clean out prior to maintenance/repair was typically followed throughout all FEMP production operations. Accordingly, the activities identified as "high" potential considered both operating and maintenance personnel.

Qualitative "low" potential ratings were assessed for low tonnage operations that were conducted intermittently; did not involve handling appreciable amounts of dry materials; and were highly reliable generally and not susceptible to off-normal events. As expected, qualitative "medium" potential ratings

were assessed for operations whose performances were not clearly "high" or "low". Exposures for these operations primarily resulted from equipment clean out prior to maintenance repair. The following table presents a summary qualitative assessment of potential dust exposure. Additional detail is provided in Appendix D, Attachment 1.

Table 2-6

Qualitative Assessment of Potential for Airborne Recycled Uranium Dusts

Potential	Plant	Area	Materials
High	5	Metal Reduction, Casting	UF_4, MgF_2, U, U_3O_8, Residues
	8	Feed Preparation Furnaces	U_3O_8, U, Residues
	4	Banks 7-9, Packaging Stations	UO_3, UO_2, UF_4
Medium	2/3	Digestion, Denitration	Prepared Feed, U_3O_8, MgF_2
	9	Reduction, Casting	UF_4, MgF_2, U, U_3O_8, Residues
	Pilot	Hex Reduction, Metal Operations	UF_4, MgF_2, U, U_3O_8, Residues
Low	6	Rolling Mill	U_3O8, Metal Scraps Residues
	1	Milling	MgF_2, U, U_3O_8, Residues

Personnel Radiation Exposure Monitoring

The potential ramifications of transuranic and fission product constituents in recycle uranium had been recognized as early as 1986 and the FEMP site radiation protection practices were adjusted to account for the trace constituent levels within the framework of the DOE radiation protection standards in effect at that time. Prior to 1986, radiation protection practices addressed recycle uranium without considering the presence of recycle-generated radiological impurities. Therefore, it may be assumed that only monitoring data prior 1986 need be considered in evaluating consequences of the constituents of concern in recycled uranium at the FEMP.

External Radiation Exposure Monitoring

Personnel monitoring, for external radiation exposure, has been performed effectively throughout site operations, starting in 1952 and continuing to the present. Early monitoring was performed via film badges. Thermoluminescent dosimeters (TLDs) have been used since 1984. Provided that external monitoring devices respond appropriately to various types of radiation, external radiation measurements are not dependent on the radionuclide that gives rise to the radiation. External radiation exposures are contained in individual exposure monitoring records for all current and former employees, since 1952 and for all subcontractors and visitors since about 1986.

Internal Radiation Exposure Monitoring

Internal radiation exposure monitoring has been performed since the 1950's using urinalysis, and since 1968 using in vivo lung monitoring. In vivo monitoring was performed using the Mobile In Vivo Radiation Monitoring Laboratory from Oak Ridge Y-12 Plant from 1968 until 1989. An onsite in vivo facility was constructed at the FEMP and has operated since 1989. However, prior to the effective date of DOE Order 5480.11 in 1989, internal monitoring data was not routinely used to estimate intake quantities and subsequent radiation doses. Rather, action levels were established for internal monitoring results that would prompt additional follow-up monitoring, evaluation of work practices and workplace conditions, and reassignment of employees to jobs with low exposure potential. Results above some threshold prompted entries of lung doses on the site's Radiation Exposure Report in the form of annual lung dose. Committed lung doses and committed effective dose equivalents were not calculated until DOE Order 5480.11 became effective.

Urinalysis

The analytical technique for uranium analysis at the FEMP has always been a chemical analysis for uranium, rather than a radiometric analysis. Consequently, intakes of uranium with dosimetrically significant quantities of transuranics or other impurities would not be viewed any differently than an intake of pure uranium. For that reason, urinalysis derived internal monitoring results likely understate actual radiological intakes when materials being handled had transuranic levels in excess of the deminimis level. Because of the variability of transuranic constituent levels, with respect to location in the plant and between processing campaigns within the recycled uranium, it is not possible to develop a standard value for the amount of dose contribution that would result from the presence of transuranic constituents.

In order to determine internal doses resulting from transuranic constituents in recycle uranium, each individual's exposure record would have to be considered on a case-by-case basis. Urinalysis results could be utilized in conjunction with knowledge of work assignments, and transuranic concentrations in recycle uranium handled at those locations to develop an estimate of the total radiological intakes and resulting internal doses. For all data prior to 1989 (it is important to note that Radiation Protection programs are believed to have adequately accounted for impurities and transuranics in recycle uranium since 1986) internal doses have not been calculated. Therefore any investigation of doses due to transuranics in recycle uranium would require a complete dose assessment, evaluating doses from uranium as well as transuranic constituents, utilizing internal monitoring results and information about the individual's workplace assignments.

In Vivo

Although in vivo measurements are radiometric measurements, the measuring technology in the Mobile In Vivo Radiation Monitoring Laboratory was not adequate to detect transuranics at levels that could have occurred at occupational exposure. Consequently, just as is the case for urinalysis results, in vivo monitoring results for uranium would have to be used along with knowledge of work assignments and transuranic levels of the material within those locations and facilities in order to estimate the total intake.

2.4.2 RMI

Operations at the RMI facility primarily handled uranium in a solid metal form. Chemical processing was limited to the oxidation of uranium fines for recovery. There were no operations at RMI believed to have the opportunity to result in concentration of recycle constituents relative to uranium.

2.4.3 WVDP

The West Valley site is considered a source site under this project, since the intent of operations at the site were to produce a plutonium product. The by-product uranyl nitrate stream was not further processed at the site, therefore relative constituent concentration did not occur.

2.4.4 WSSRAP

Due to the similarities in the processes and equipment, the descriptions used for the FEMP (Section 2.4.1) would similarly apply to the WSSRAP operations. However, since natural uranium accounted for more than 97 percent of the uranium processed at the site, there is little or no chance that the remaining 3 percent of the uranium contributed significant quantities of recycle constituents for concentration in site processes.

2.5 ACTIVITIES THAT CAUSED REPORTABLE ENVIRONMENTAL RELEASES OF RECYCLED URANIUM

The operational history of the four sites addressed within this report included activities that are known or suspected of causing reportable environmental releases of recycled uranium to the environment. Each of the sites, the FEMP, RMI, WVDP, and WSSRAP, have ongoing DOE funded remediation and decommissioning activities in progress. As a result, the nature and extent of historical releases to the environment via airborne and liquid discharges are well quantified and thoroughly documented. Through qualitative evaluation of these environmental documents and the operational history of the sites with respect to recycled uranium, an evaluation of the activities that could have potentially caused reportable releases of recycled uranium are able to be constructed. The remainder of this section provides a general

discussion on known and potential environmental releases of recycled uranium from routine and non-routine operations.

2.5.1 FEMP

Historical uranium releases, both airborne and liquid, at the FEMP are addressed in this section through discussions of the release mechanisms, routine discharges from production operations, significant episodic releases from plant operations, and non-production source releases of primary contamination. The next few paragraphs provide a summary of the site's airborne environmental releases as quantified by the FEMP Operable Unit 5 Remedial Investigation Report. Following the discussion of airborne releases, text documenting the routine and non-routine discharge of aqueous/liquid discharges is discussed. A more thorough discussion of this information is presented in Appendix E.3, FEMP Historical Environmental Releases.

Plant process operations were limited to a fenced, 136-acre tract known as the production area. Liquid and solid wastes that were generated by the various chemical and metallurgical processes were stored or disposed of in the waste storage area located west of the production area. The cessation of production operations in 1989 essentially eliminated further primary releases to environmental media; secondary release mechanisms and resultant contaminant migration are continuing.

Primary Airborne Discharges From Production Operations

Uranium processing operations within the FEMP production cycle resulted in both routine and episodic releases of airborne radiological contaminants to environmental media. Airborne particles and gases were generated during most production, storage and handling operations over the years of processing uranium materials. The principal sources of routine airborne emissions from process operations were dust collector discharges, wet scrubber discharges, and acid-pickling fume stacks. Episodic releases resulted from unplanned incidents arising from human error, equipment malfunctions, procedures, or situational conditions. Emissions of uranium from non-production sources included those from waste management storage practices, incinerator operations and building exhausts. Fugitive dust generated from the waste storage pits can be attributed to load-in/load-out operations, wind erosion of stored materials, and vehicle movement in the storage area. Five non-production solid/liquid waste incinerators supported the general site operations. Exhausts from buildings located within the production area and the laboratory contributed uranium releases.

Routine operations at the FEMP resulted in occasional discharges from the process stacks and by-products, which were handled in a variety of ways. Contamination of environmental media resulted from releases during process operations and from handling and disposition of the by-products that were treated as waste streams. Descriptions of process operations and waste management practices are presented from a broad perspective of how these activities contaminated the environmental media. The total airborne emissions since site operations began in 1951 amount to 179 MTU. The total value for all routine airborne releases were determined by summing the estimated and measured uranium emissions from a number of process stacks and vents. For the purpose of analysis of potential recycled uranium releases, only releases from 1961 through 1987 were considered, inasmuch as airborne emissions prior that time would not have contained recycled or irradiated uranium and its constituents of concern.

Uranium discharges from monitored stacks were the only measured emissions. This value has been estimated to include approximately 73 MTU that was released after recycled uranium operations were initiated at the FEMP in February 1961.

The principal sources of airborne emissions from FEMP processing operations were:

- Dust collector stack discharges
- Wet scrubber discharges
- Acid-pickling fume stacks.

It is significant to note that the largest quantity of uranium was discharged from FEMP operations that took place prior to 1961, e.g. approximately 63%, and, therefore, would not have involved recycled uranium.

Dust Collector Stack Discharges

Dust collector stack discharges were the principal sources of airborne emissions during the span of FEMP operations from 1951 to 1984. Airborne releases of recycled uranium from plant stacks (1961 to 1984) has been estimated to total 19.4 MTU and are characterized as follows (Table 2-7):

TABLE 2-7

FEMP URANIUM DISCHARGES FROM MONITORED STACKS

Uranium Emmissions (kg) by Source

	Dust Collectors												
Calendar Year	Plant 1	Plant 2/3[a]	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Pilot Plant[b]	Plant 8 Wet Scrubbers[c]	Non-Production Sources[d]	Other Sources[e,f]	Total Emissions[g]
1951	--	--	--	--	--	--	--	--	123	--	--	2	125.0
1952	--	--	--	--	6	--	--	--	493	--	--	44	543.0
1953	3.8	6	1473	90	12	--	--	--	493	--	--	105	2,182.8
1954	46.2	281	5890	4119	28	4261	201	0	271	217	15	157	15,486.2
1955	46.2	1113	12,450	10,410	53	7268	877	0	443	948	118	167	33,893.2
1956	43.4	1978	5145	3501	27	1743	1316	0	32	1442	118	174	15,519.4
1957	49.4	3730	814	3664.4	35		791	0.4	18	1575	118	230	11,025.2
1958	407.4	3520	661	715	161		875	679	27	1650	118	242	9,055.4
1959	46	3929	1428	478.4	127		260	417	34	2100	118	240	9,177.4
1960	20	4233	212	202.8	268		298	219	718	2604	118	260	9,152.8
Total 1951-1960	**662.4**	**18790**	**28073**	**23180.6**	**717**	**13272**	**4618**	**1315.4**	**2652**	**10536**	**723**	**1621**	**106,160.4**
1961	52.8	3707	262	76.2	119		209	67.4	174	2271	118	271	7,427.4
1962	14	2137	703	356	59		618	135	174	2304	138	304	6,942.0
1963	82.6	0	1469	783	181		994	159	51.8	2171	145	339	6,375.4
1964	18	0	545	330.4	34		1051	252	13	2865	145	330	5,583.4
1965	4.1	192.7	334.7	226.5	42.6		390	68	10	5810	146.2	269	7,493.8
1966	12.2	514	227.7	76.7	11.3		327	48.5	1213.1	926	152	222	3,730.5
1967	20.4	646.8	279.9	147.9	2.7		417	76.2	11.8	1790	152	181	3,725.7
1968	0.5	1119.5	267.2	88	30.4		901	121	3.6	3082	152	120	5,885.2
1969	27.2	698.2	49.4	119.3	2.7		424	12.7	3.6	3123	128	120	4,708.1
1970	4.5	356.7	29.9	53.1	0		569	13.6	0	666	105	185	1,982.8
1971	9	306	0	0	0		91	0	0	541	105	40	1,092.0
1972	28.4	1360	9	33	0		5	24	0	--	105	37	1,601.4
1973	1	1396	57	79	0		14	15	0	39	105	33	1,739.0
1974	1.4	2445	24.4	40	0		11	38	0	--	105	32	2,696.8
1975	5.6	2844.7	119.8	19	0		3.5	0	0.4	--	105	40	3,138.0
1976	2.7	3339.2	26.1	13.7	2.4		7.2	2.8	0	--	105	40	3,539.1
1977	0.6	756.2	11.8	53.3	0		4.6	0	10.4	--	105	36	977.9
1978	1.8	0	11.9	29.1	0		0	72	2.2	--	105	39	261.0
1979	0.8	0	46.3	12.3	0		0	2.3	0	--	93	45	199.7
1980	13.4	2.7	133.8	89.5	0		5.1	0	3.3	11	7.7	50	316.5
1981	1.3	30	432.1	135.6	0		0	0	0	10	8.2	60	677.2
1982	2.1	52.3	21	121.8	0.5		81.2	5.1	0	37	8.8	65	394.8
1983	6.4	130	42.9	41.4	0		24.7	0	0	58	7.8	65	376.2
1984	12.1	574.3	39.6	83.9	1		8.1	170.9	2.8	38	16.8	66	1,013.5
Total 1961 - 1984	**322.9**	**22,608.3**	**5,143.5**	**3,008.7**	**486.6**	**0.0**	**6,155.4**	**1,283.5**	**1,674.0**	**25,742.0**	**2,363.5**	**2,989.0**	**71,877.4**
1985										66,424.9		64	315.3
1986												68	130.2
1987												60	302.3
Total 1961 - 1987												**3,455.6**	**72,997.2**

*Reference: FEMP Operable Unit 5 Remedial Investigation Report

[a] Includes emissions from gulping of uranium trioxide

[b] Includes 1195 kg unmonitored release of UF_6 on February 14, 1966.

[c] Data are on a fiscal year basis: 1952-1976 July 1-June 30; 1976 transition; and 1977 and after, October 1- September 30

[d] Consists of:

Old solid waste incinerator	2474.7 kg
Old burner (1962-1979)	462.9 kg

[e] Includes other process emissions, buildings exhausts, laboratory emissions, fugitive emissions from waste pits, and nonroutine events.

[f] Includes an additional 272 kg from nonroutine events not distributed over production years (concentrated liquid uranyl nitrate hexahydrate releases).

[g] Some totals differ from other published reports but differences are insignificant.

The Plant 8 scrubbers discharged an additional 25,742 kg U (25.7 MTU), primarily in the form of uranyl ammonium phosphate (UAP) and uranous tetrachloride (UCl_4) from the dissolution of U-metal in hydrochloric acid. Each plant discharged dust as uranium residues from processing operations. Plants 4, 5, and 9 discharged UO_2F_2 as a companion side-product contained in UF_4. Estimates of dust collector discharges from all FEMP processing plants categorized by U species follow:

TABLE 2-8

DUST COLLECTOR DISCHARGES BY URANIUM SPECIES (1961-1984)

Uranium Species	kg Recycled U[a]	Percent of Total
Ores	556	3
U_3O_8, UO_2	15,797	81
UO_3	148	<1
UF_4	2,432	12
UO_2F_2	40	<<1
UCl_4	19	<<1
UAP[b], ADU[c]	371	2
Total	19,363 or 19.4 MTU	100

[a]Value presented have been adjusted to remove estimated non-recycled uranium releases for 1960 and part of 1961.
[b]Uranyl ammonium phosphate
[c]Diammonium diuranate

Ninety-one percent of the recycled uranium discharges were oxides and green salt. It should be noted that dust collector discharges from Plants 2/3 and 8, when combined with emissions from gulping operations and the wet scrubber discharges, together accounted for approximately 75 percent of the discharges between 1961 and 1984 (54,506 kg U or 54.5 MTU). A breakdown of uranium stack discharges by plant, species and time is summarized in Appendix E.3.

Wet Scrubber and Acid-Pickling Discharges

Wet scrubber discharges since 1961 resulted from Plant 2/3 gulping operations and other scrubbers operating in Plant 8. Acid-pickling operations in Plants 6 and 9 further contributed to these uranium emissions. Releases of 21,590 kg U as uranyl nitrate are estimated from the Plant 2/3 gulping operations and 25,742 kg U from the Plant 8 wet scrubbers. Emissions from the Plant 6 and 9 acid-pickling sources are judged to be relatively insignificant. The impact of these emissions to the environmental media is in the discharge of acidic vapors that are conducive to promoting solubilization of particulate uranium species released from other sources.

Dose Reconstruction Project Release Estimates

A draft a report entitled, "The Fernald Dosimetry Reconstruction Project - Radionuclide Source Terms and Uncertainties," was issued in June 1995 by the Radiological Assessments Corporation (RAC) under contract to the Centers for Disease Control (CDC). The RAC report was prepared to support an initiative being undertaken by the CDC to reconstruct the potential radiological doses received by members of the public residing around the FEMP as a result of environmental discharges during the facility's 38-year operational history.

Within the CDC report, RAC evaluated the projected quantities and characteristics of radiological contaminants released to the environment from facility operations. Existing FEMP historical release estimates, as presented in the DOE's remedial investigation/feasibility study (RI/FS) documents, were based upon an evaluation of historical stack monitoring data and production records by FEMP scientific staff members. The RAC estimates employed a probabilistic approach to projecting these same historical release levels.

The probabilistic-based estimates completed by RAC included use of Monte Carlo methods to evaluate the propagation of uncertainty in the estimating process. These Monte Carlo simulations were completed for total site dust collector emissions, Plant 8 scrubber emissions, Plant 2/3 scrubber discharges, and radon released from the site. In general, the best estimate of the mass of releases from these sources, as projected by RAC, were, on average, somewhat higher than similar estimates completed by the FEMP. The primary differences reside in the estimation of releases from the Plant 8 and the site-wide dust collection systems.

No attempt has been made to reconcile the differences between the two estimates of total mass of historical site emissions. For the purposes of this report, the historical estimates developed by former FEMP technical staff are considered a better tool to estimate the potential airborne release of recycled uranium and its constituents of concern to the environment.

Significant Episodic Releases from Plant Operations

Plant 7 Releases of UF_6 in 1954-55

Eyewitness accounts have stated frequent releases of UF_6 during the start-up and early operation of Plant 7 in the 1954 period. During these incidents, building windows were closed and laboratory ventilation hoods were shutdown until the visible white plume of UF_6 dissipated from cylinders placed on-line for operations. Quantities released as UF_6 have been estimated to be 252 kg U during the

operation of Plant 7. Since the operation of Plant 7 did not include recycled uranium or feedstocks made from recycled uranium, none of these releases are pertinent with regard to this project's scope. Since the timing of this release is prior to 1961, it is concluded that this release did not involve recycled uranium or its constituents of concern.

Pilot Plant Releases of UF_6 in 1966

On February 14, 1966, an unmonitored release of 1,195 kg U as UF_6 occurred during a one-hour period, beginning at 8:40 a.m. At that time winds were from the north/northwest at 5 mph. The release point was about 6 feet above the ground and resulted from a valve being inadvertently removed. Release of another 264 kg U have been estimated for other intermittent periods of operation. Using historical records and analysis indicate that the level of recycled uranium constituents of concern released during these events, totaling 1.5 MTU, would have been as represented in the following table:

TABLE 2-9
FEMP RELEASE FROM PILOT PLANT (1.5 MTU)

Constituent for UF_6	Pu	Np	Tc
Value in ppb	0.502 ppb	54.90 ppb	201.61 ppb
Amount in grams	0.0g	0.0g	0.0g

Plant 2/3 Releases of UNH/Nitric Acid Vapor

Quantities of uranium were emitted from the Plant 2/3 gulping system as a vapor mist of UNH solution in nitric acid. These emissions occurred when $U0_3$ was removed by vacuum gulping from denitration pots. During the period of recycled uranium operations, estimates of 22,608.3 kg U discharged were identified based on uranium production records, measurements of U content in acid mists, and collection efficiency expected from the entire particulate control system. Releases totaling approximately 272 kg U have been documented incidents. All of these releases are assumed to include recycled uranium and its constituents of concern. Using historical records and analysis, it has been calculated that these releases, totaling 22.6 MTU, would result as represented in the following table:

TABLE 2-10
FEMP RELEASE FROM PLANT 2/3 (22.6 MTU)

Constituent for UO_3	Pu	Np	Tc
Value in ppb	23.969 ppb	1,045.29 ppb	2,789.56 ppb
Amount in grams	0.5 g	23.6 g	63.0 g

Other Non-routine Production Discharges

Emissions of uranium from metal fires and solid spills estimated based on two specifically occurring outdoors have been estimated to be 907 kg U and 1059 kg U, respectively, over the period of FEMP operations through 1984. Uranium metal fires generally occurred on the east storage pads of Plants 6 and 8, where drums of machining chips and turnings were stored for the pickling and briquetting operations. Outdoor spills amounting to 37 kg U occurred during the interplant shipment of uranium compounds, usually from a drum falling from a transport trailer. Using historical records and analysis indicate that the level of recycled uranium constituents of concern released during this event, totaling 2.1 MTU, as represented in the following table:

TABLE 2-11

FEMP OTHER NON-ROUTINE PRODUCTION (2.1 MTU)

Constituent for Metal	Pu	Np	Tc
Value in ppb	2.884 ppb	388.97 ppb	8552.33 ppb
Amount in grams	0.0 g	0.8 g	18.0 g

Non-Production Source Releases of Primary Contamination

Incineration

Five non-production incinerators supported the general site operations. Discharges from these incinerators were as follows;

- Old solid waste incinerator at the sewage treatment plant (2,480 kg U or 2.5 MTU)
- Oil burner (463 kg U or 0.5 MTU)
- Graphite burner (125 kg U or 0.1 MTU)
- New solid waste incinerator (12 kg U or 0.0 MTU)
- Liquid organic waste incinerator (17 kg U or 0.0 MTU)

Potential recycled uranium releases from these sources are estimated to be 3,097 kg U (3.1 MTU) for the FEMP's operational period. The likely form of airborne discharges from the five non-production burners and incinerators is U_3O_8, because these units functioned to oxidize the lower oxidation state uranium compounds. The oil burner and liquid waste incinerator processed hydrocarbons whose residue could have contained phosphorous in a uranium oxide matrix. Likewise, the old solid waste incinerator could have contained phosphorous plus metal oxides in a uranium oxide matrix. The graphite burner operated only on contaminated graphite and only yielded U_3O_8 as the carbon burned off. The new solid waste incinerator operated mostly on miscellaneous contaminated trash (paper, cardboard, wood, etc.) that

yielded only U_3O_8. Any lower oxidation state uranium compound would not remain after processing under incineration conditions of heat and air. It is possible that quantities of phosphorous or fluoride compounds would exist to some extent given that a wide variety of chemical processing took place, but the likely form of release is U_3O_8. Using historical records and analysis indicate that the level of recycled uranium constituents of concern released during this event, from 3.1 MTU, as represented in the following table:

TABLE 2-12

FEMP RELEASE FROM INCINERATION (3.1 MTU)

Constituent for U_3O_8	Pu	Np	Tc
Value in ppb	23.969 ppb	1,045.29 ppb	2,789.56 ppb
Amount in grams	0.1 g	3.2 g	8.6 g

Storage

Up to 1984, on-property disposal of solid and slurried wastes at the FEMP occurred in pits and silos. Transport of solid wastes to the pits was dependent on the type of wastes generated and the type of storage containers. In general, drummed wastes were transported on flatbed trailers; metal dumpsters were carried by dumpster vehicles; bulk wastes were transported by dump trucks and trailers; and drummed pyrophoric metal was conveyed on four-wheeled flatbed trailers. At the waste storage area, dump trucks, dump trailers, dumpster units, and drummed wastes were emptied directly onto the pits' edges. The material was then pushed into the pits by either a bulldozer or a dragline scraper. Loose contamination was washed from bulldozers, the dragline - scraper, vehicles, dumpsters, and fork trucks with water at the pits. Fugitive airborne uranium emissions at the waste pits have been estimated to be 1,022 kg U (1.0 MTU) for the FEMP recycled uranium operational period through 1984. Using historical records and analysis indicate that the level of recycled uranium constituents of concern released during this event of 1.0 MTU is represented in the following table:

TABLE 2-13

FEMP RELEASE FROM STORAGE (1.0 MTU)

Constituent for Waste	Pu	Np	Tc
Value in ppb	84.817 ppb	3,999.32 ppb	4,110.05 ppb
Amount in grams	0.1 g	4.0 g	4.1 g

Other Airborne Emissions

Estimates of uranium releases from building exhausts and laboratory emissions have been estimated to be 228 kg U (0.2 MTU) and 48 kg U (0.0 MTU), respectively, for the FEMP recycled uranium operational period through 1984. The likely form of release is U_3O_8 or intermediate uranium compounds specific to each processing plant. Using historical records and analysis indicate that the level of recycled uranium constituents of concern released during this event is represented in the following table:

TABLE 2-14
FEMP RELEASE FROM OTHER AIRBORNE EMISSIONS (0.3 MTU)

Constituent for U_3O_8	Pu	Np	Tc
Value in ppb	16.035 ppb	1,328.11 ppb	2,399.22 ppb
Amount in grams	0.0 g	0.4 g	0.7 g

Liquid Waste Discharges from FEMP

Liquid wastes that were generated during production operations at the FEMP came from three main sources: process water via the Clearwell portion of the waste pit, sanitary sewage, and storm water. Site liquid effluent streams were released to the offsite environment at two locations. These locations are 1) the combined sewer outfall that discharges through the FEMP National Pollution Discharge Elimination System (NPDES) monitoring point at Manhole 175 into the Great Miami River, and 2) the site storm water outfall ditches which discharged into Paddy's Run on the western and southwestern boundary of the site.

Manhole 175, located on the eastern side of the facility, was the discharge point for wastewater leaving the site through the main effluent line to the Great Miami River. It is the final junction point of the major waste effluent streams from the facility. The discharge flow to the Great Miami River was continuously measured. A composite sample was collected and analyzed for uranium on a daily basis. These daily uranium measurements were obtained for most years of production. Much of the information and compilation of historical effluent releases to the Great Miami River used in this report were obtained from "The Fernald Dosimetry Reconstruction Project, Task 2 and 3," prepared by Radiological Assessments Corporation.

The quantity of uranium released to the river is the product of the uranium concentration multiplied by the flow volume. Sources of uncertainty for these estimates of uranium losses through Manhole 175 to the

Great Miami River primarily come from analytical errors in measuring effluent flow and in sampling and measuring uranium concentrations in the water.

Storm water resulting from natural precipitation typically passed through the storm sewer lift station before being released to the Great Miami River via Manhole 175. Since the storm sewer lift station was not, during production operations periods, connected to any process, all uranium lost through it was assumed to be from leaks, spills, and erosion. When the capacity of the storm sewer lift station was reached during precipitation events, water overflowed through the storm sewer outfalls to Paddy's Run. Hence, FEMP liquid effluent releases to Paddy's Run can be shown to directly correlate to rainfall amounts and patterns.

Estimates for uranium losses from storm water outfall to Paddy's Run are based upon analytical data sheets and monthly reports that listed outfall events occurring during that month. There are three components of uncertainty associated with the estimation of uranium losses to Paddy's Run:

- The analytical errors associated with determining uranium concentration and water flow before discharge to Paddy's Run.
- Time periods when rainfall, and consequently runoff, were high and the capacity of the storm sewer lift station exceeded.
- Unmeasured losses from the site above the point where the storm sewer outfall enters Paddy's Run.

Figure 2-2 shows the annual uranium release estimates to the Great Miami River and to Paddy's Run for all years. The magnitude of uranium releases to the river peaked in 1961 at approximately 7,300 kg U (7.3 MTU). From 1974 onward, the annual releases were below 1000 kg U (1.0 MTU). The uranium losses to Paddy's Run show much more month-to-month variation than do the releases to the Great Miami River through Manhole 175. However, RAC determined that the average quantity of 500kg U (0.5 MTU) discharged through Manhole 175 to the Great Miami River each month during the early 1960s was roughly five times greater that the average quantity of 100 kg U (0.1 MTU) lost to Paddy's Run.

Table 2-15 summarizes the best estimates for releases of materials in liquid effluents from the FEMP for the period of recycled uranium operations of 1961 through 1988. The best estimate for release of uranium to the Great Miami River is 55,390 kg U (55.4 MTU). These estimates compare very favorably with historical documents prepared by former FEMP prime contractors that quantified annual discharges (Boback 1971) or in summary reports evaluating the past discharge history of the facility (Rathgens 1974,

Boback et al., 1985). These estimates of uranium to surface water from 1951 through 1984 range from 74,000 to 77,000 kg U (74.0 to 77.0 MTU) (Boback et al. 1987, Galper 1988).

The total release estimate for recycled uranium and its constituents to Paddy's Run via the storm sewer outfall ditch and runoff is 11,104 kg U (11.1 MTU). Losses to Paddy's Run show considerable month-to-month variation, as expected by the fact that it was only used during extreme flow conditions.

Summary Data from the Fernald Dosimetry Reconstruction Project Tasks 2 and 3, source Terms and Uncertainties. Table L-5 Annual Uranium Losses to the Great Miami River By Way of MH 175 with Uncertainty Range (kg). Table L-8 Annual Uranium Losses to Paddy's run With Uncertainty Estimates.

Based on the data presented in the previous few paragraphs, it has been estimated that the total liquid effluent discharge to the environment of recycled uranium and its constituents is approximately 66,500 kg U (66.5 MTU). Using historical information and analyses, it is estimated that this quantity of liquid discharges is represented in Table 2-16.

FIGURE 2-2
FEMP LIQUID DISCHARGES

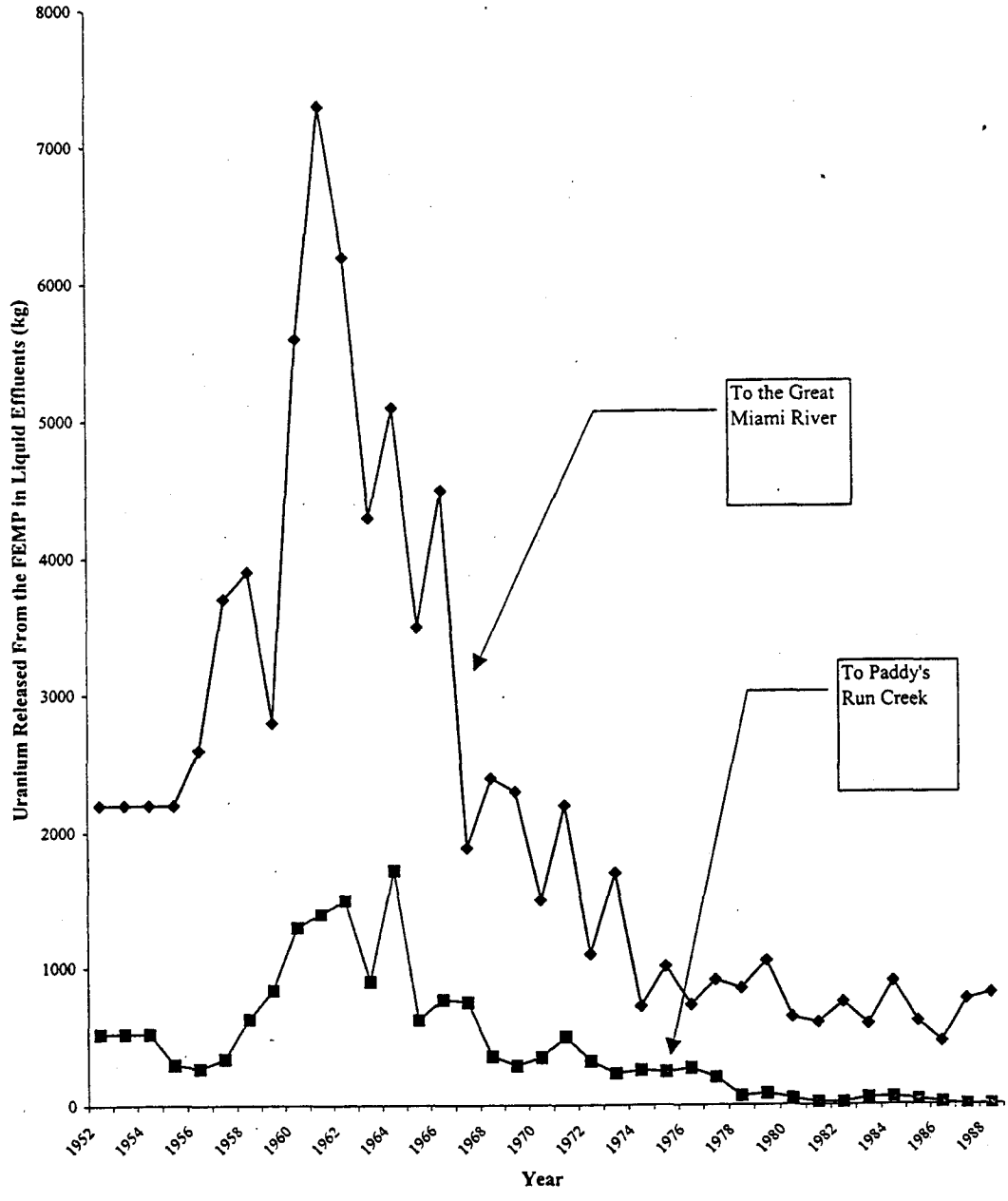

TABLE 2-15

FEMP LIQUID DISCHARGES (1961-1988)

Year	Great Miami River Total U (Kg)	Paddy's Run U (Kg)
1961	7,300	1,400
1962	6,200	1,500
1963	4,300	901
1964	5,100	1,722
1965	3,500	622
1966	4,500	771
1967	1,890	753
1968	2,400	358
1969	2,300	290
1970	1,500	349
1971	2,200	499
1972	1,100	322
1973	1,700	231
1974	720	255
1975	1,010	245
1976	730	272
1977	910	204
1978	850	68
1979	1,050	84
1980	640	50
1981	600	20
1982	750	20
1983	590	54
1984	900	57
1985	610	39
1986	460	17
1987	770	0.5
1988	810	0.5
Total	55,390 or 55.4 MTU	11,104 or 11.1 MTU

TABLE 2-16

FEMP RELEASE FROM LIQUID EFFLUENT DISCHARGES (66.5 MTU)

Constituent in Effluent	Pu	Np	Tc
Value in ppb	16.035 ppb	1,328.11 ppb	2,399.22 ppb
Amount in grams	1.1 g	88.3 g	159.5 g

In conclusion, the FEMP had routine and non-routine airborne and liquid effluent releases of recycled uranium and its constituents to the environment that have been estimated to total approximately 170.2 MTU. Using representative constituent values for each of these releases, it is estimated that roughly 2.0 g Pu-239, 148.9 g of Np-237, and 879.5 g of Tc-99 could have be attributed to these releases.

2.5.2 RMI

Over the span of operation of the RMI Extrusion Facility from 1962 through the present, a radiation protection program commensurate with requirements and regulations in effect at a given time was in place. The primary exposure concern was uranium; however, the same controls would be used for transuranics. In the earlier years, personnel monitoring was accomplished with a bioassay sampling program and area air sampling. Exposure limits were based on limits in effect at the time.

Engineering controls, such as ventilation, were also used for exposure control. Ventilation stacks were used for some processes and building ventilation was achieved using Q-jets. Monitoring was conducted for gaseous effluent and liquid effluents.

As regulatory limits became more restrictive, the program was adjusted to incorporate the new limits. Breathing zone sampling was added to the program. In the later years, more efficient HEPA filters were added to ventilation systems.

In conclusion, over the life of the site programs to monitor personnel exposure and effluent streams were in place and used to achieve compliance with limits in effect at the time. This program provided adequate protection for personnel and the environment. Therefore, RMI Environmental Services, Inc. has concluded that no discussion of potential worker exposure to recycled uranium or concerning the potential release of recycled uranium to the environment is warranted.

2.5.3 WVDP

The WVDP is a plutonium reprocessing facility for spent nuclear fuel, and as such, is a source site per the DOE-HQ Recycled Uranium Project Plan. Based on this distinction, any potential worker exposure and/or environmental release does not need to be addressed or quantified as recycled uranium. Therefore, the DOE Ohio Field Office Recycled Uranium Project Report team has determined that the following information is provided merely to ensure that data is available should the West Valley classification as a source site change in the future. For purposes of this document, no environmental release of recycled uranium or its constituents of concern have been assumed to have taken place during the West Valley operational history. Documentation of historical releases of irradiated uranium and its transuranic and fission products constituents for the WVDP fuel reprocessing operations are scarce at best. A limited quantity of historical documentation on WVDP operations and discharges were recovered and used to compile this text. The WVDP historical documents used to develop this section include:

1. Review of the operating history of the Nuclear Fuel Service, Inc., West Valley, New York Irradiated Fuel Reprocessing Plant, December 1980, E.R. Johnson Associates, Reston, Virginia.
2. Nuclear Fuel Services, Inc., West Valley Reprocessing Plant Quarterly Reports, various, Nuclear Fuel Services, Inc., West Valley, New York.

These documents, while providing a detailed description of historical environmental releases during fuel reprocessing operations at the WVDP, do not compile or address quantifiable environmental release data for recycle uranium, plutonium, neptunium or technetium.

Radioactive Effluents

The operation of the fuel reprocessing plant at the WVDP resulted in the release of both gaseous and liquid radioactive materials. This release was entirely expected and was subject tot he limits of concentration established by 10 CFR 20. The gaseous release was primarily krypton-85 which is a fission product and a beta emitter with a half-life of 10.4 years. The predominant radionuclide in the liquid releases tritium (H-3), which is a product of ternary fission and a beta emitter with a half life of 12.3 years.

The airborne releases were through the plant stack after scrubbing, treatment for removal of radioiodine, and filtration. The release occurred during the dissolution of irradiated fuel and, therefore, the gaseous activity released is directly correlated in time with plant operation. Liquid wastes, on the other hand, were collected in tanks, held in on-site lagoons, and finally, released at a controlled rate to the natural drainage system of the site.

Historical records indicate that the amount of radioactive material released to the environment would have been roughly in proportion to the radiation exposure of the fuel. This proportionality would persist in spite of the length of time elapsed between removal of the fuel from the reactor and its dissolution as long as that time period was more than a few years. There is little available data on the "age" or elapsed time for the fuel reprocessed at WVDP but it is believed to have been on the order of five years. The radiation exposure of the fuel may be characterized by the total energy produced by the fuel. Historical records and data indicated that the activity of the liquid effluents was reasonably constant over the six-year life of the plant. The tritium activity released was of the order of 100 Curies per month although it was nearer to 10 Curies per month in 1966 and reached peaks of 1000 Curies per month in 1969. Hanford N-Reactor spent fuels were reprocessed periodically from 1966 through 1971. A total of 11of the 27 fuel reprocessing campaigns involved N-Reactor irradiated fuel (Appendix B, Table B-1). Gross beta activity, exclusive of the tritium activity, released was of the order of 10 Curies per month with peak values in 1969 of 40 Curies per month. Historical data shows that when plant operations were ceased, the release of gaseous activity was also halted.

Liquid Effluents

The liquid effluents at WVDP fuel reprocessing operations were generated from evaporator condensates, floor drains, laundry, and decontamination operations. These low-level wastes were collected in holding tanks from which they were released to on-site ponds. Release from the holding tanks was permitted when the combined gross alpha and beta activity was less than 5×10^{-3} pCi/ml. The release was to a series of three ponds each draining into the next with the last discharging to Buttermilk Creak via Erdmann Brook and Frank's Creek. Buttermilk Creek joins Cattaraugus Creek at a point within the NFS property limits; thus Cattaraugus Creek is the first surface stream exiting the site after receiving radioactive effluent and was designated as the control point for measuring offsite aqueous release.

The activity of samples from Pond 3 was measured monthly by NFS; the measured activity per unit sample volume and measured volumetric release rate permitted calculation of total released activity. Table 2-17 is a summary by quarters of the NFS data as presented in their quarterly reports to the AEC over the period from April 19, 1966, to December 31, 1972. The beta activity shown is exclusive of the separately measured tritium activity. Scanning of the table indicates that:

(1) tritium was by far the principal radionuclide released and;
(2) the released activity peaked in 1969;
(3) the alpha activities can be correlated to plutonium and uranium releases.

An evaluation of the beta activity spectrum is available from analysis of the liquid effluent based on samples taken from the interceptor tanks in the plant from April to September, 1969 and from Pond 3 from May to October 1969 (1). Based on the samples from Pond 3, this study reported that "thirty three times more tritium was discharged ... than any other radionuclide." Table 2-18 is taken from this study. It identifies the sources of beta activity exclusive of tritium activity.

TABLE 2-17

WVDP LIQUID RELEASES, NFS DATA[a]
DISCHARGED ACTIVITY (Ci)

Year	Quarter	∝	β	H-3	Sr-90	I-129	Highest % MPC Cattaraugas Creek
1966	2	.008	0.3	20	-	-	-
	3	.006	2.8	68	-		-
	4	.020	5.1	58	-		-
1967	1	.022	7.9	1080	-		
	2	.012	3.6	1218	0.75		20.4
	3	.005	4.2	1380	0.42	-	29.8
	4	.016	22.6	526	8.30	.070	12.6
1968	1	.106	15.6	920	2.41	.006	10.6
	2	.008	5.4	356	0.99	.009	6.5
	3	.009	4.7	925	0.46	.005	16.5
	4	.016	20.7	441	1.17	.008	15.9
1969	1	.254	20.4	1125	1.03	.020	22.7
	2	.058	4.4	2041	0.49	.040	22.9
	3	.027	35.0	773	3.53	.132	50
	4	.037	36.3	2037	5.02	.008	32.7
1970	1	.041	29.1	1695	3.73	.019	38.9
	2	.012	18.4	1019	4.11	.020	12.9
	3	.018	26.8	930	4.18	.086	49.7
	4	.032	12.6	872	2.21	.216	25.6
1971	1	.011	18.6	1424	2.47	.064	12.8
	2	.017	29.9	672	2.60	.085	21.2
	3	.009	14.3	946	1.29	.047	17.2
	4	.019	14.3	812	0.29	.014	16.1
1972	1	.012	16.0	261	0.53	.006	11.0
	2	.006	10.7	213	0.11	.040	9.2
	3	.003	12.1	89	0.02	.004	6.5
	4	.005	4.1	42	0.01	.004	3.6

MPC for $\beta = 1 \times 10^{-5}$ µCi/ml

MPC for $\propto = 5 \times 10^{-6}$ µCi/ml

[a]From data reported in the Quarterly Progress Reports (2)

TABLE 2-18

WVDP SOURCES OF BETA ACTIVITY IN LIQUID EFFLUENT

Radionuclide	Percent of Beta Activity (Exclusive of H-3 Activity)
Ru-106	73
Sr-90	12
Cs-137	11
Cs-134	3
Ce-144	0.2
Pm-147	0.1
Zr-93	<0.1
Co-60	0.3
Sb-123	0.8
Mn-34	<0.1

The alpha activity in the lagoon samples was due to isotopes of uranium and plutonium. Tables 2-19A and 2-19B are extracted from a report on liquid effluents from the West Valley Plant, by Magno, et al (1). Table 2-19A gives measured activity in the sample and calculated release of each isotope based on the flow rate from the lagoon during the month of October 1969; similar data were obtained for each month from May through October.

Table 2-19B presents the total plutonium activity discharged by month and the total for the six-month period. Several interesting observations can be made from the data obtained by Magno. Based on plutonium analyses on composite samples of liquid effluents discharged from the plant to the interceptor during the period April 1 through September 14, 1969, there was a substantial reduction of the concentration of plutonium in effluent, in passing through the lagoon, presumably due to absorption on sediments; similar observations were made on all other radioisotopes. Strontium and uranium are least reduced in passing through the lagoons; plutonium, cerium, and promethium are reduced to 2 percent of their input values.

TABLE 2-19

A. WVDP PLUTONIUM AND URANIUM CONCENTRATIONS IN LAGOON 3 COMPOSITE SAMPLE, OCTOBER 1969

Radionuclide	Sample Activity, μCi/ml			Activity Discharged (Curies)
	Total	Dissolved	Suspended	
Pu-238	4.7×10^{-9}	0.2×10^{-9}	4.5×10^{-9}	5.8×10^{-5}
Pu-239	6.3×10^{-9}	0.3×10^{-9}	6.0×10^{-9}	7.7×10^{-5}
Pu-241	4.0×10^{-7}	$< 3 \times 10^{-7}$	4.0×10^{-7}	4.9×10^{-3}
Pu-232	2.4×10^{-7}	2.2×10^{-7}	0.2×10^{-7}	3.0×10^{-3}
Pu-234	9.0×10^{-8}	8.3×10^{-8}	0.7×10^{-8}	1.1×10^{-3}
Pu-238	$9.0 \times 10x^{-9}$	8.4×10^{-9}	0.6×10^{-9}	1.1×10^{-5}

B. WVDP PLUTONIUM DISCHARGES BY MONTH, MAY-OCTOBER 1969 CONCENTRATION (MICROCURIES/MILLILITER)

Isotope	May	June	July	August	September	October	Total Release (Ci)
Pu-238	2×10^{-8}	9.7×10^{-9}	1.4×10^{-8}	6.9×10^{-9}	3.2×10^{-9}	4.7×10^{-9}	6.3×10^{-4}
Pu-239	3.2×10^{-8}	1.7×10^{-8}	3.7×10^{-8}	6.7×10^{-9}	3.6×10^{-9}	6.3×10^{-9}	1.2×10^{-3}
Pu-241	2.2×10^{-6}	7.0×10^{-7}	2.6×10^{-6}	4.4×10^{-7}	$< 4 \times 10^{-7}$	4.0×10^{-7}	7.5×10^{-2}
		Total Alpha Activity					1.8×10^{-3}

Although the amount of plutonium alpha discharged activity over the six month period is small, 0.002 Ci, the more important consideration is that the concentrations, as measured in the lagoon discharge, are a factor of 1000 under the allowable limits of 10CFR20, Appendix B, Table II valid during the WVDP fuel reprocessing timeframe. The study reports furthermore, that the activity due to Pu-239 in samples from Buttermilk Creek on November 4, 1969 was less than 1×10^{-11} μCi/ml for dissolved solids and 1.8×10^{11} μCi/ml for suspended solids. Prior to the sampling on November 4, waste had been discharged from Pond 3 continuously since October 31 at a rate of 60 gal/min. The measured concentration for Pu-239 was still a factor of one million less than the pertinent 1969 requirements of 10CFR20 Appendix B, Table II for water.

Total liquid radioactive effluent releases, exclusive of tritium, never resulted in radioactivity levels of Cattaragus Creek, which exceeded 50 percent of the maximum permissible concentration (MPC). Tritium levels at the Cattaragus Creek sampling station, based on measurements made in July and November 1969 were 1.0 percent and 0.11 percent of applicable MPC limits, respectively.

Airborne Effluents

The process off-gas treatment systems included the dissolver off-gas system, which consisted of a scrubber, silver reactors, and absolute filters, and the vessel off-gas system, which consisted of a scrubber and absolute filters. A small flow of ventilation air through the shear plenum joined the dissolver off-gas stream between the scrubber and the iodine reactor. Waste tank off-gas, the third process system, was passed through filters before joining the other system at the stack. The intent of the process off-gas systems was to remove radioactive iodine isotopes, particulate matter, and aerosols generated in the dissolver or in process vessels by air-sparging; no attempt was made to remove tritium or the noble gas fission products.

The purpose of the building ventilation system was to provide conditioned air to the working areas, to provide a flow of ventilation air from areas of lesser contamination, through areas of intermediate level, and finally through the high level cells; the ventilation air was relied on to remove heat from the cells, though this, according to some observers, provided inadequate heat remove. Building ventilation was exhausted to the stack after passing through absolute filters; this system provided backup to filters installed in the Chemical Process Cell and the Process Mechanical Cell and also removed particulate picked up by the ventilation air in other cells.

All four streams joined at or near the stack; a monitoring station in the stack took an isokinetic sample of the stack gas, and conducted it to an analytical station. Routine measurements were made of particulate Kr-85, and I-131 activity. Considerable difficulty was encountered with the original sampler installation, due to a long transport line from the stack to the instrument. The presence of a number of bends in this line resulted in there being a considerable question as to the validity of the particulate analyses (3). The system was subsequently revised to place the particulate collection and measuring unit at the stack (4). The revised system was put in service in March 1967 (5).

Table 2-20 is a summary by quarters of the WVDP airborne release data as presented in the NFS quarterly reports to the AEC over the period from April 19, 1966 to December 31, 1972. With respect to the data of this table, it may be noted that:

a) the bursts of particulate activity in 1967 and 1968 were associated with failures of filters (processing campaigns in 1967 and 1968 included irradiated N-Reactor fuel);

b) release of I-131 activity was generally below detectable limits, but that would have been expected since the half life of I-131 is eight days and the fuel processed had been out of the reactor for about one year or more;

TABLE 2-20

WVDP AIRBORNE RELEASES, NFS DATA[a]

		Particulate		Krypton-85		Iodine-131	
Year	Quarter	MCi	Maximum % Monthly Limit	(10^3Ci)	Maximum % Daily Limit	(mCi)	CUM % Yearly Limit
1966	2	11		2		0	
	3	89		46		0.23	
	4	75		29		0	
1967	1	53		52		0	
	2	164		76		0	
	3	241		134		0	
	4	25		66		0	
1968	1	452		36		6.4	
	2	397		480		0.21	
	3	135	26.0		8.5		1
	4	79	17.4		11.0		1
1969	1	94	28.2		13		1
	2	5	0.5		44		1
	3	3	0.6		19		1
	4	17	4.5		19		1
1970	1	8	1.7		39		1
	2	73	21.0		44		1
	3	77	13.9		34		1
	4	19	3.9		36		1
1971	1	4	0.8		56.6		1
	2	4	0.7		29.5		1
	3	2	0.3		41.9		1
	4	4	1.2		41.2		1
1972	1	46	12.3		0		1
	2	48	8.8		0		1
	3	38	7.4		0		1
	4	16	2.5		0		1
Limits		0.1	Ci/sec	12.6 x 10^3Ci/day		3.3 Ci/yr	

[a]From information reported in Quarterly Progress Reports [2]

c) The Kr-85 activity released was considerable but always within the daily limit of 12,600 Curies.

The expected gaseous radioactive input to the process off-gas system was given in Table 2-21. The distribution of tritium among the off-gas, liquid effluent, and high level waste streams in the ratio 25:65:10. The predicted discharge of radioiodines was based on an estimated removal efficiency of 99.5 percent. It is doubtful that this efficiency was ever attained. There is an indication in a later survey for I-129 (6) that the "silver reactors... were largely ineffective for iodine absorption."

TABLE 2-21

WVDP PREDICTED AIRBORNE ACTIVITIES FROM REPROCESSED FUEL FOR 1 MTU, 20,000 MWD/MTU, 150 DAY COOLING

Radionuclide	Activity Released from Fuel	Activity Discharged from Stack
Kr-85	6300	6300
I-129	.022	1.1×10^{-4}
I-131	1.8	9.0×10^{-3}
Xe-131m	1.0	1.0
Xe-133	.0038	.0038
H-3	50	50

In 1969, the U.S. Public Health Service (USPHS) undertook a preliminary study of airborne radioactive effluents around the NFS plant (7); in this study a stack sampler and four field stations were used to measure Kr-85, I-129, and H-3activity; particulate activity was measured at the stack and one field station. These measurements were conducted on June 12 and 14, 1969 during the processing of Yankee fuel.

These values may also be compared with the discharged activity reported by NFS for the month of June 1969, which was that a maximum of 44 percent of the daily limits for Kr-85 had been reached. With the limit of 12,600 Ci/day, the 44 percent corresponds to a release of 5,544 Curies; thus, the NSF reported value is greater than either of the USPHS measurements but is of similar magnitude. It is quite likely that the NFS maximum occurred on a different day in the Yankee campaign.

In addition to Kr-85 measurements, the USPHS report also gives results for H-3 and I-129 activity at the stack. The release over specific time intervals, as shown in Table 2-22, was as follows:

TABLE 2-22

WVDP STACK DISCHARGES BY INTERVALS IN JUNE 1969

Date	Time Interval	Stack Discharge	
		Tritiated Water Vapor (Ci)	I-129 (μCi)
6/12/69	0845-1200	6.8×10^{-2}	8.4×10^{2}
6/12/69	1210-1400	6.2×10^{-2}	3.1×10^{2}
6/14/69	1045-1340	4.7×10^{-2}	1.4×10^{3}
6/14/69	1342-1535	4.4×10^{-2}	7.9×10^{2}

Extrapolating these measurements to the dissolution operations indicates that about 1.5 percent of the total tritium available in the fuel was discharged as water vapor and that from 5 to 10 percent of the I_{129} was discharged as airborne effluent. The iodine discharge was high due tot he ineffectiveness of the silver reactors. The discharge of significant amounts of I_{129} is a matter of concern since its half-life is 17 million years and it is, therefore, essentially a permanent environmental contaminant. Since the WVDP site was a plutonium processing facility, it is not being categorized as having recycled uranium.

2.5.4 Weldon Spring

Historical information concerning environmental releases from the Weldon Spring site in St. Charles, Missouri is not readily available. Due to the extended period of time that has elapsed since uranium operations were curtailed in 1966 and to the brief re-utilization of the site by the Department of Defense in the late 1960s and early 1970s, many of the site's records were archived without significant cataloging. Hence, the efforts to reconstruct historical releases of recycled uranium and its associated constituents of concern have had to rely on summary level data compiled to support WSSRAP environmental restoration activities. Table 2-22 Total Discharges for the Weldon Spring Plant Operations presents the available data for historical airborne and liquid releases of depleted, normal, and enriched uranium to the environment. This data was originally compiled and presented as Table 2 in DOE/OR-872, Historical Nuclear Materials Balance Report for the Former AEC-Owned Weldon Spring Chemical Plant (July 1986).

TABLE 2-23

WSSRAP TOTAL DISCHARGES FOR PLANT OPERATIONS

Element	Airborne via Stacks (KgU)	Aqueous via Sewers (KgU)	Aqueous via Raffinate Pits (KgU)	Total (KgU)
Natural Uranium	44,741	26,720	152,382	223,843
Depleted Uranium	0	0	46	46
Enriched Uranium	300	979	2,808	4,087
Total	45,041	27,699	155,236	227,976

Based on the data presented in Table 2-23 above, it has been concluded that the total discharge of recycled uranium and its constituents to the environment is approximately 228,000 kg U (228 MTU). Using historical information and analysis on similar materials processed at Fernald, the total discharge of contaminants of concern from 228 MTU can be estimated as follows:

TABLE 2-24

WSSRAP CONSTITUENT RELEASES TO THE ENVIRONMENT FROM OPERATIONS

Constituent Released	Pu	Np	Tc
Value in ppb	0.091 ppb	67.09 ppb	26.55 ppb
Amount in grams	0.0 g	12.3 g	4.9 g

Note: This includes releases of DU, NU, and EU via stacks, sewers and to raffinate pits.

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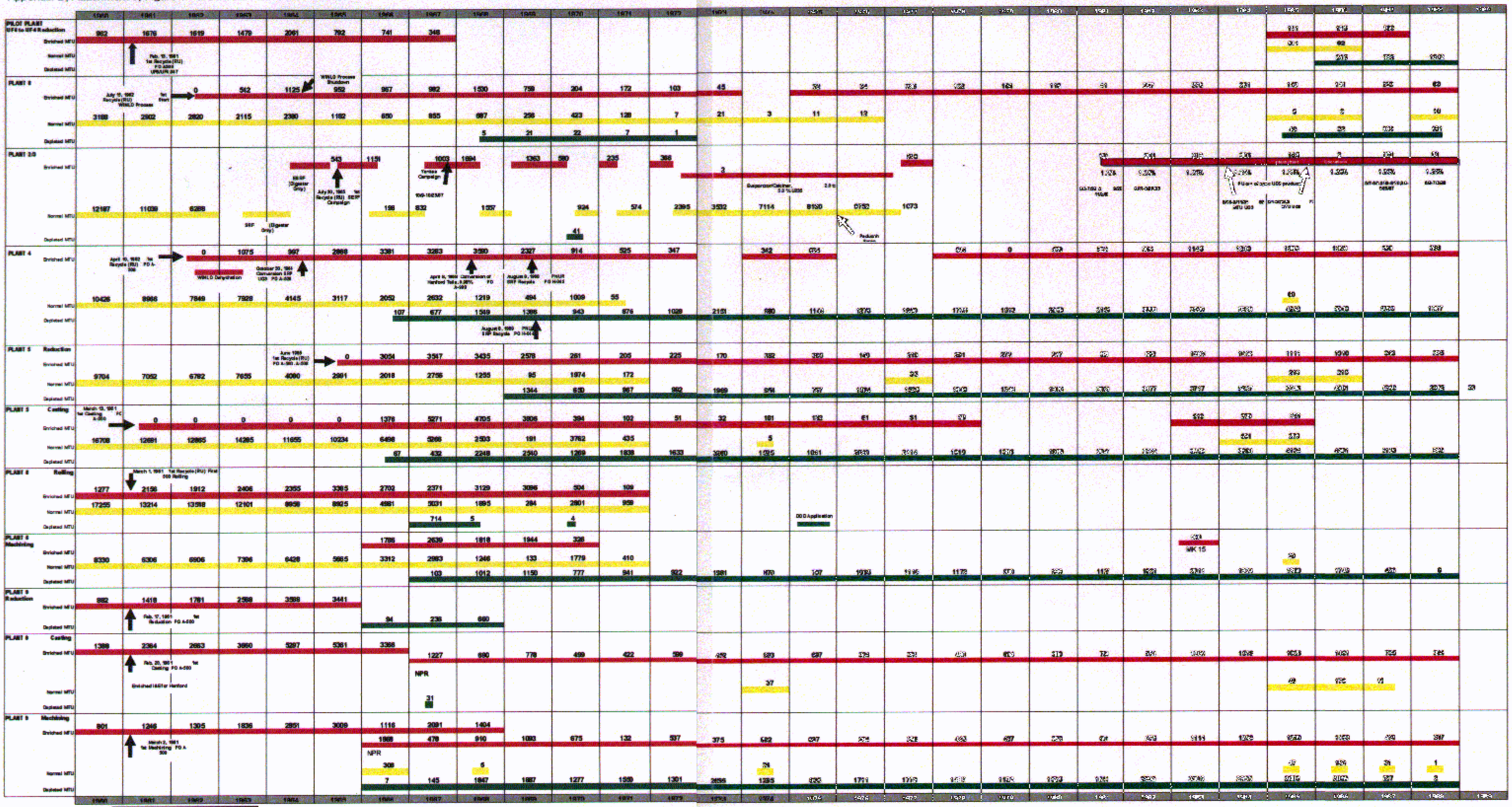
Appendix D, Attachment 3, Figure 1 URANIUM FLOW AT THE FERNALD SITE BY FISCAL YEAR



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